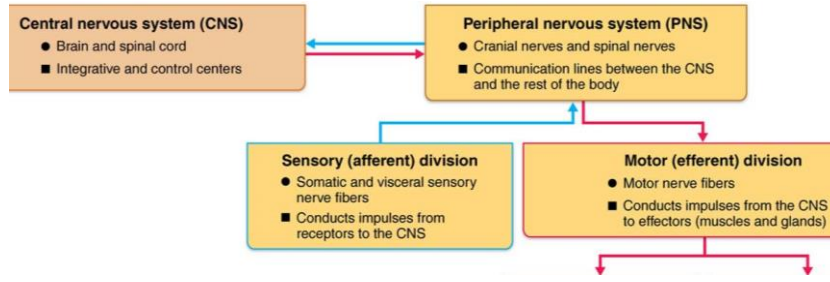
Biology 232, Chapter 12: The Central Nervous System (CNS)



- Part 1: intro to the CNS
- Part 2: the spinal cord
- Part 3: brain overview
- Part 4: specific brain parts

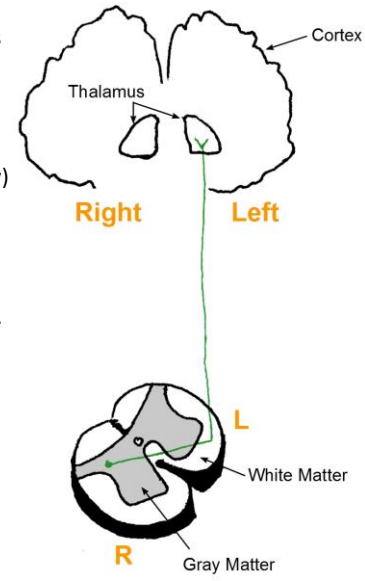
Hoehn et al. (2025), Figure 11.3

1

Ch. 11 introduced the nervous system. We now have several more nervous system chapters... Ch. 12 = CNS = spinal cord + brain. Ch. 13 = peripheral NS (PNS). Ch. 14 = autonomic NS (ANS). Ch. 15 = special senses.

TQT 12.1.1 (LG 2). Given a name or picture of a (real or fictitious) CNS tract, identify that tract as afferent/ascending/sensory or as efferent/descending/motor, or identify the location of its cell bodies or axon terminals.

- STRATEGY: Determine whether the neurons are going from the spinal cord to the brain (sensory) or from the brain to the spinal cord (motor). Note whether any tract names begin with "Spino-" or end with "-spinal."
- Example A: In the picture at right, a green neuron runs between the brain and spinal cord. Does this neuron carry sensory information, or motor information? Explain how you can tell.



2

TQT 12.1.1. **Example A:** It must be sensory because the neuron starts with a cell body in the spinal cord and ends with an axon terminal in the brain, meaning that it is carrying information upward from the spinal cord to the brain. If information is coming INTO the brain it must be sensory information.

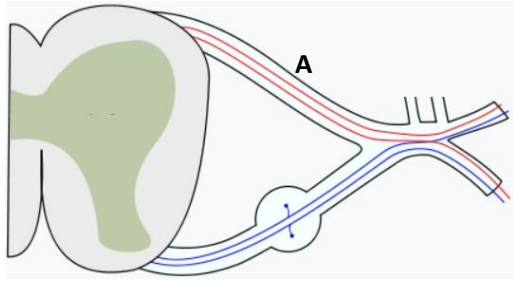
TQT 12.1.1 (LG 2). Given a name or picture of a (real or fictitious) CNS tract, identify that tract as afferent/ascending/sensory or as efferent/descending/motor, or identify the location of its cell bodies or axon terminals.

- STRATEGY: Determine whether the neurons are going from the spinal cord to the brain (sensory) or from the brain to the spinal cord (motor). Note whether any tract names begin with "Spino-" or end with "-spinal."
- Example B: An alien is similar to humans except for having somewhat different spinal cord tracts. Is its basospinal tract motor or sensory? Would its cell bodies be found in the brain, or in the spinal cord? Explain how you can tell, based on the name of the tract.
- Example C: Make up an example and ask your classmates!

3

TQT 12.2.1 (LG 2). Given cross-sectional pictures of the spinal cord (possibly including surrounding nerves), identify white matter and dorsal/ventral (posterior/anterior) horns/roots.

- STRATEGY: First determine which side is dorsal and which is ventral!
- Example A: In the picture below, does the letter A mark a horn, a spinal root, or neither? Explain your reasoning.

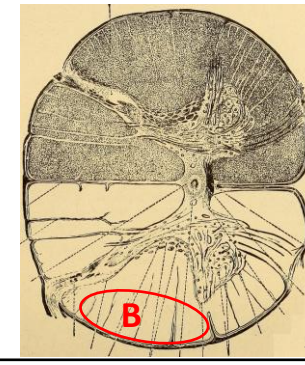


4

TQT 12.2.1. **Example A:** This must be a spinal root, being lateral to the spinal cord itself but medial to the point where the dorsal and ventral roots converge. It must be a ventral root because it's on the opposite side of the root with the ganglion (must be a dorsal root ganglion) and on the same side as the relatively rounded ventral horns.

TQT 12.2.1 (LG 2). Given cross-sectional pictures of the spinal cord (possibly including surrounding nerves), identify white matter and dorsal/ventral (posterior/anterior) horns/roots.

- STRATEGY: First determine which side is dorsal and which is ventral!
- Example B: Does the specific area marked "B" carry sensory information, motor information, or both? Explain your reasoning.
- Example C: make up an example and ask your classmates!



Church & Salinger (1908) via Internet Archive Book Images on Flickr (public domain)

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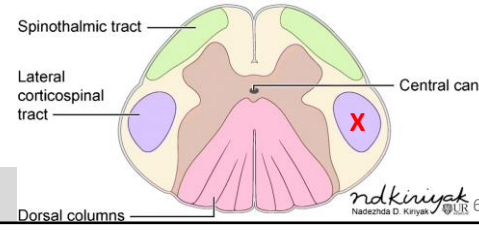
TQT 12.2.2 (LG 5). Given a picture or description of damage to a specific area of the spinal cord or spinal roots, make general predictions about symptoms (i.e., sensory vs. motor vs. both). Or vice versa: given general symptoms, infer areas of damage.

- STRATEGY: First orient yourself anatomically (e.g., dorsal vs. ventral), then connect anatomic location to function (sensory vs. motor vs. both).
- Example A: The red X in the figure below right marks the area of an injury. Would you predict the most likely symptoms to be sensory impairment, motor impairment, or both? Explain your reasoning.



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TQT 12.2.2. **Example A:** X is in a lateral corticospinal tract of the white matter. From the name “corticospinal” (the label of the same tract on the opposite side), you can tell that this is a descending/efferent tract carrying motor information, so impairment of motor functions (weakness, paralysis) would be expected.

TQT 12.2.2 (LG 5). Given a picture or description of damage to a specific area of the spinal cord or spinal roots, make general predictions about symptoms (i.e., sensory vs. motor vs. both). Or vice versa: given general symptoms, infer areas of damage.

- STRATEGY: First orient yourself anatomically (e.g., dorsal vs. ventral), then connect anatomic location to function (sensory vs. motor vs. both).
- Example B: A herniated intervertebral disc pinches a dorsal root. Would you predict the most likely symptoms to be sensory impairment, motor impairment, or both? Explain your reasoning.
- Example C: make up an example and ask your classmates!

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TQT 12.4.1 (LG 3). Given information about (real or hypothetical) CNS fibers, classify them as association fibers, commissural fibers, or projection fibers.

- STRATEGY: Apply the definitions of the 3 types. If fibers connect the two cerebral hemispheres, they're commissural fibers. If the fibers travel vertically into and out of the cerebrum, they're projection fibers.
- Example A: Imagine a tract of fibers that connect the right visual cortex with the right premotor cortex. Are these fibers best classified as association fibers, commissural fibers, or projection fibers? Explain your reasoning.

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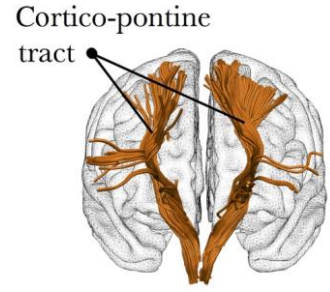
TQT 12.4.1. **Example A:** These fibers connect two parts of the cerebrum without crossing between the right and left hemispheres, so they would be association fibers, which by definition connect different parts of the same cerebral hemisphere.

TQT 12.4.1 (LG 3). Given information about (real or hypothetical) CNS fibers, classify them as association fibers, commissural fibers, or projection fibers.

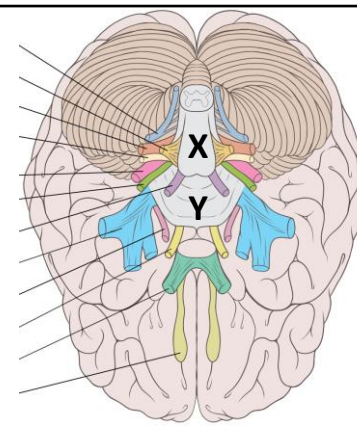
- STRATEGY: Apply the definitions of the 3 types. If fibers connect the two cerebral hemispheres, they're commissural fibers. If the fibers travel vertically into and out of the cerebrum, they're projection fibers.
- Example B: Would the cortico-pontine tract (below right) consist of association fibers, commissural fibers, or projection fibers? Explain your reasoning.
- Example C: Make up an example and ask your classmates!



Thiebaut de Schotten et al. (2015), *Cerebral Cortex* 25(12): 4812-4827

TQT 12.4.2 (LG 1). Given two or more brain structures, answer questions about their spatial relationships.

- STRATEGY: Review the directional terms from Chapter 1 (lateral/medial, dorsal/ventral, etc.) to make sure you can apply them to brain parts.
- Example A: In the picture at right, structure X is ____ to structure Y.
  - (A) anterior
  - (B) inferior
  - (C) lateral
  - (D) medial



TQT 12.4.2. **Example A:** (B) inferior.

TQT 12.4.2 (LG 1). Given two or more brain structures, answer questions about their spatial relationships.

- STRATEGY: Review the directional terms from Chapter 1 (lateral/medial, dorsal/ventral, etc.) to make sure you can apply them to brain parts. Beware of different possible views
- Example B: Of the caudate nucleus head, globus pallidus, and putamen, which is most lateral?
- Example C: make up an example and ask your classmates!

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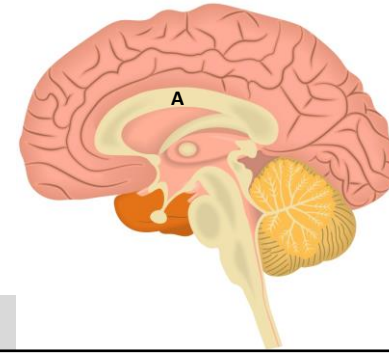
TQT 12.4.3 (LG 5). Given damage to a highlighted structure (among those we've covered) in a picture of the brain, predict functional deficits.

- STRATEGY: Identify the brain area that is marked, then recall the function(s) of that area and assume the function(s) will be impaired.
- Example A: What are the likely functional consequences of damage to structure "A" below? Include the name of structure "A" in your answer.



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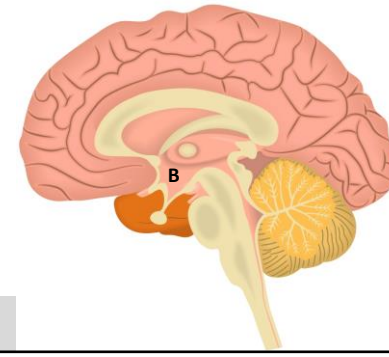
TQT 12.4.3. **Example A:** This is the corpus callosum, so damage might impair communication between the left and right hemispheres of the brain.

TQT 12.4.3 (LG 5). Given damage to a highlighted structure (among those we've covered) in a picture of the brain, predict functional deficits.

- STRATEGY: Identify the brain area that is marked, then recall the function(s) of that area and assume the function(s) will be impaired.
- Example B: What are the likely functional consequences of damage to structure "B" below? Include the name of structure "B" in your answer.
- Example C: make up an example and ask your classmates!



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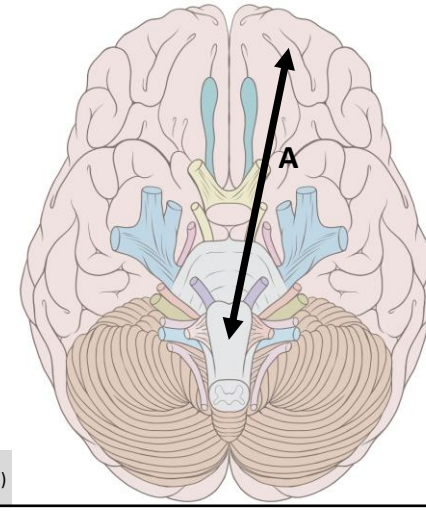
TQT 12.4.4 (LG 5). Given a (real or hypothetical) tract in the brain, predict the tract's function from its location.

- STRATEGY: Identify the areas where the tract starts and ends, and predict a function based on the function(s) of those two locations.
- Example A: What would be the likely function of a brain pathway represented by arrow A? Explain your reasoning.

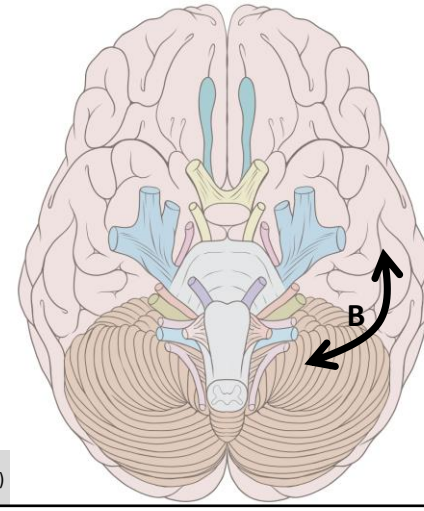


TQT 12.4.4. **Example A:** Arrow A connects the marks the medulla oblongata (relay of sensory and motor info, regulation of BP/HR/breathing) with the prefrontal cortex (planning, personality, etc.) So there is some room for interpretation here. For instance, if a person if feeling nervous about something, one could imagine that aspect of personality feeding from the prefrontal cortex into the medulla oblongata and affecting heart rate.

TQT 12.4.4 (LG 5). Given a (real or hypothetical) tract in the brain, predict the tract's function from its location.

- STRATEGY: Identify the areas where the tract starts and ends, and predict a function based on the function(s) of those two locations.

- Example B: What would be the likely function of a pathway represented by arrow B? Explain your reasoning.
- Example C: Make up an example and ask your classmates.



TQT 12.4.5. Given a pathway from the thalamus to the cerebral cortex, predict the modality of sensory information carried by that pathway.

- STRATEGY: Determine where in the cortex the pathway is ending, then deduce the sensory modality from that location.
- Example A: Researchers are studying neurons that stretch from the thalamus to the occipital lobe of the cerebral cortex. What kind of sensory information is carried by these neurons? Explain your reasoning.

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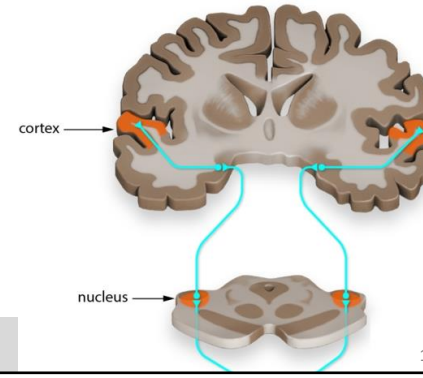
TQT 12.4.5. **Example A:** The information should be visual information, since that's the focus of the occipital lobe.

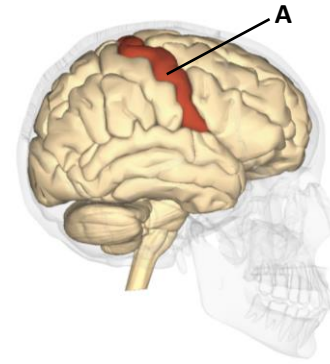
TQT 12.4.5. Given a pathway from the thalamus to the cerebral cortex, predict the modality of sensory information carried by that pathway.

- STRATEGY: Determine where in the cortex the pathway is ending, then deduce the sensory modality from that location.
- Example B: In the pathway below, neurons run from a nucleus of the thalamus to an area of the cerebral cortex. What kind of sensory information is most likely being transmitted along this pathway? Explain your reasoning.
- Example C: Make up an example and ask your classmates!



TQT 12.4.6 (LG5). Given a modality of information (sensory or motor) and a location on the body (including side: left or right), identify the approximate location in the cerebral cortex that is responsible for this information. Or vice versa, i.e., given a cerebral cortical location, identify the information being processed there.

- STRATEGY: Carefully distinguish the precentral gyrus (primary motor cortex) from the postcentral gyrus (primary somatosensory cortex). Remember that each side of the brain controls the opposite side of the body.
- Example A: Neurons at location A at right are highly active. What is going on? That is, is location A receiving sensory information or sending out motor commands, and which side of the body is this information coming from or going to? Explain your reasoning.



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TQT 12.4.6. **Example A:** Location A is part of the primary motor cortex, so motor commands would be coming from this location. Since A is in the right primary motor cortex, the motor commands would be going to muscles on the left side of the body (e.g., left biceps brachii).

TQT 12.4.6 (LG5). Given a modality of information (sensory or motor) and a location on the body (including side: left or right), identify the approximate location in the cerebral cortex that is responsible for this information. Or vice versa, i.e., given a cerebral cortical location, identify the information being processed there.

- STRATEGY: Distinguish the precentral gyrus (primary motor cortex) from the postcentral gyrus (primary somatosensory cortex). Remember that each side of the brain controls the opposite side of the body.
- Example B: Your child is stomping in puddles, and some drops of water hit your right thigh. Within the cerebral cortex, is this stimulus perceived in the left postcentral gyrus, left precentral gyrus, right postcentral gyrus, or right precentral gyrus? Explain your reasoning.
- Example C: make up an example and ask your classmates!

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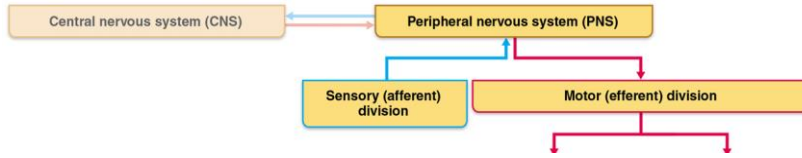
Chapter 13: The Peripheral Nervous System and Reflexes



- Part 1: nerve basics
- Part 2: cranial nerve overview
- Part 3: cranial nerve gallery
- Part 4: spinal nerves
- Part 5: spinal nerve plexuses
- Part 6: reflexes

Hoehn et al. (2035), Figure 13.1

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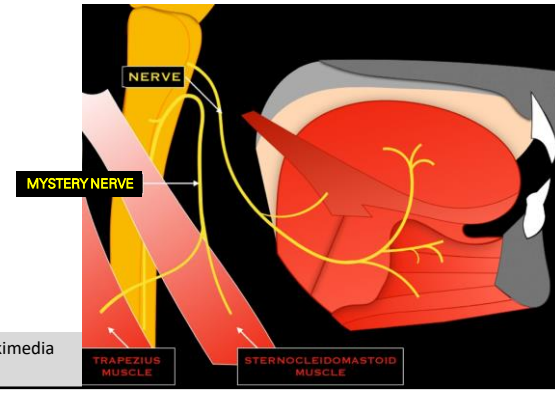
TQT 13.3.1 (LG 2). Given information about a cranial nerve, choose the correct identity by explaining how you can rule out the other options.

- STRATEGY: Use differences in the anatomy (locations of connections to brain and/or peripheral destinations) and/or function of the cranial nerves in question.
- Example A: Is the "MYSTERY NERVE" below cranial nerve X, XI, or XII? Explain how you can rule out each of the incorrect options.



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TQT 13.3.1. **Example A:** Answers will vary. For example, this nerve only has 2 visible branches, both of which go to head/neck skeletal muscles that are not the tongue. This is consistent with the destinations of cranial nerve XI (accessory), but not the destinations of cranial nerve X (goes to many thoracic and abdominal locations) or cranial nerve XII (goes to various tongue muscles).

TQT 13.3.1 (LG 2). Given anatomical information about a cranial nerve, choose the correct identity by explaining how you can rule out the other options.

- STRATEGY: Use differences in the anatomy (locations of connections to brain and/or peripheral destinations) of the cranial nerves in question.
- Example B: As you perform surgery on an anaesthetized laboratory rat, you are poking around in the area of cranial nerves VII and VIII when you touch one of these nerves, prompting the rat's cheek and forehead muscles to twitch, meaning that the nerve you touched must innervate some skeletal muscles of the face. Which nerve did you touch? Explain how you can rule out the incorrect option.
- Example C: Make up an example and ask your classmates!

TQT 13.3.2 (LG 2). Given specific cranium holes, demonstrate knowledge of their identity by answering questions about the cranial nerves that run through them.

- STRATEGY: First identify the hole, then recall which nerves pass through that hole, then answer the question.
- Example A: In a particular patient, a hole for blood vessels and nerves between the temporal bone and the occipital bone has been partly occluded (blocked). Could this occlusion explain reduced sensation from this patient's tongue? Explain your reasoning.

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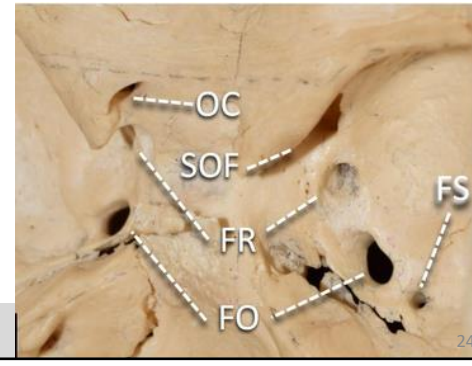
TQT 13.3.2. **Example A:** Yes! The hole in question is the jugular foramen. Cranial nerves IX, X, and XI run through this hole, and IX and X contribute to taste, which is consistent with the problem described.

TQT 13.3.2 (LG 2). Given specific cranium holes, demonstrate knowledge of their identity by answering questions about the cranial nerves that run through them.

- STRATEGY: First identify the hole, then recall which nerves pass through that hole, then answer the question.
- Example B: Below is a portion of the anterior inferior cranium. Which cranial nerve or nerves pass through the opening labeled FR? Explain your reasoning.
- Example C: Make up a problem and ask your classmates!



Bryan Edwards et al. (2018), *Cureus* 10(2):e2172 (CC BY 3.0)

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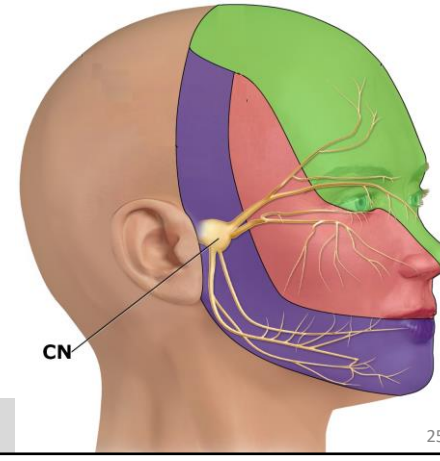
TQT 13.3.3 (LG 5). If given a functional test or symptom, determine which cranial nerve(s) is/are most relevant, or vice versa (i.e., given the possibility of a damaged nerve, propose possible symptoms or functional tests).

- STRATEGY: Apply a mnemonic to recall the main functions of relevant cranial nerves.
- Example A: See the cranial nerve labeled "CN" below. Could an injury to this cranial nerve be responsible for blindness or visual impairment? Explain your reasoning.



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TQT 13.3.3. **Example A:** No – this is cranial nerve V (trigeminal), which does not collect sensory information from the eyes. Cranial nerve II (optic) is the one that carries visual information from the eyes toward the brain.

TQT 13.3.3 (LG 5). If given a functional test or symptom, determine which cranial nerve(s) is/are most relevant, or vice versa (i.e., given the possibility of a damaged nerve, propose possible symptoms or functional tests).

- STRATEGY: Apply a mnemonic to recall the main functions of relevant cranial nerves.

- Example B: A nurse places a drop of lemon juice on a patient's tongue to see whether it will cause saliva to be produced. Which cranial nerve(s) could be checked in this way? Explain your reasoning.
- Example C: make up an example and ask your classmates!

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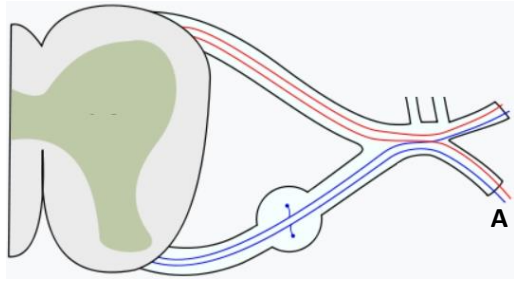
TQT 13.4.1 (LG 5). Given an area of a cross-section of the spinal cord and/or spinal roots and rami, determine whether that area carries sensory information or motor information or both.

- STRATEGY: Determine which side is dorsal and which is ventral (if needed), then identify the specific area marked and recall its function.
- Example A: Does the specific section of nerve marked "A" carry sensory information, motor information, or both? Explain your reasoning.



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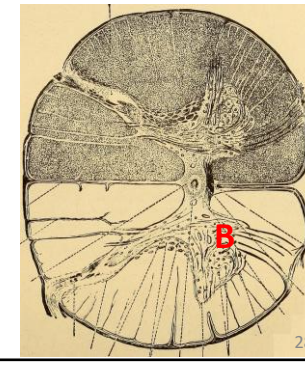
TQT 13.4.1. **Example A:** This is a ramus, being lateral to the area where the dorsal and ventral roots converge, so it carries both sensory and motor information. (This is also indicated with the neurons color-coded in the usual way: blue = sensory, red = motor.)

TQT 13.4.1 (LG 5). Given an area of a cross-sectional picture of the spinal cord (possibly including surrounding nerves), determine whether that area carries sensory information or motor information or both.

- STRATEGY: Determine which side is dorsal and which is ventral (if needed), then identify the specific area marked and recall its function.
- Example B: Does the specific section of spinal cord marked "B" carry sensory information, motor information, or both? Explain your reasoning.
- Example C: make up an example and ask your classmates!



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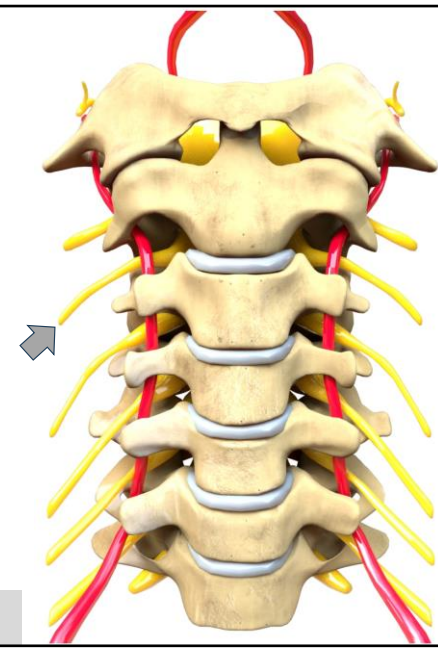
TQT 13.4.2 (LG 2). Given information about vertebrae and/or the spinal cord, identify a particular spinal nerve or vertebra by letter and number (e.g., C_5 or T_9).

- STRATEGY: Determine whether you are in the cervical area or below that and apply the relevant vertebra/nerve rule.
- Example A: In the picture at right, which shows all cervical vertebrae, which spinal nerve is indicated by the arrow? Explain how you can tell.



TQT 13.4.2. **Example A:** Spinal nerve C_3. This nerve emerges from above the C_3 vertebra, so it must be the C_3 nerve. You could also count down from the C_1 nerve, though that is small and looks different from the ones below it.

TQT 13.4.2 (LG 2). Given information about vertebrae and/or the spinal cord, identify a particular spinal nerve or vertebra by letter and number (e.g., C_5 or T_9).

- STRATEGY: Determine whether you are in the cervical area or below that and apply the relevant vertebra/nerve rule.
- Example B: Spinal nerve T_4 passes through the intervertebral foramen between two vertebrae. Which is the lower vertebra? Explain how you can tell.
- Example C: make up an example and ask your classmates!

TQT 13.5.1. Given a muscle covered in a Chapter 10 lab list, give the spinal nerve plexus (if any) that innervates it.

- STRATEGY: Localize the muscle to the upper limb, lower limb, or neither, then choose the appropriate plexus (if any).
- Example A: Which spinal nerve plexus, if any, controls the biceps femoris muscle? Explain your reasoning.

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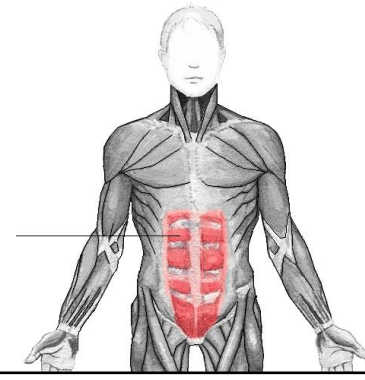
TQT 13.5.1. **Example A:** The biceps femoris muscle is found in the lower limb and therefore would be innervated by the lumbosacral plexus.

TQT 13.5.1. Given a muscle covered in a Chapter 10 lab list, give the spinal nerve plexus (if any) that innervates it.

- STRATEGY: Localize the muscle to the upper limb, lower limb, or neither, then choose the appropriate plexus (if any).
- Example B: Which spinal nerve plexus, if any, controls the muscle highlighted below at right? Explain your reasoning.
- Example C: Make up an example and ask your classmates!



TQT 13.5.2. Given a muscle covered in a Chapter 10 lab list, choose its spinal-cord innervation from a multiple-choice list.

- STRATEGY: Localize the muscle to the upper limb, lower limb, or neither, then choose the option that falls into the appropriate plexus or the appropriate range of nerves between plexuses.
- Example A: Which spinal nerves innervate the biceps femoris muscle?
  - (A) C_5-C_6
  - (B) T_2-T_3
  - (C) T_{10}-T_{11}
  - (D) L_5-S_3

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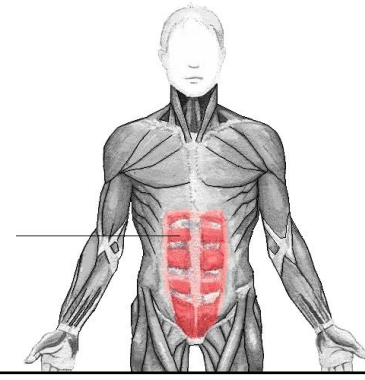
TQT 13.5.2. **Example A:** (D) L_5-S_3.

TQT 13.5.2. Given a muscle covered in a Chapter 10 lab list, choose its spinal-cord innervation from a multiple-choice list.

- STRATEGY: Localize the muscle to the upper limb, lower limb, or neither, then choose the option that falls into the appropriate plexus or the appropriate range of nerves between plexuses.

- Example B: Which spinal nerves innervate the muscle highlighted below at right?
  - (A) C_3-C_5
  - (B) T_7-T_{12}
  - (C) L_1-L_3
  - (D) S_1-S_3
- Example C: Make up an example and ask your classmates!



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TQT 13.5.3 (LG 5). Given a picture or description of damage to a specific area of the spinal cord or spinal nerves, predict symptoms (e.g., sensory vs. motor, upper limbs vs. lower limbs). Or vice versa (i.e., given symptoms, predict the area of damage).

- STRATEGY: Use any available clues to decide between sensory deficits vs. motor deficits vs. both, but also consider whether the deficit will be limited to a specific spinal level (damage to gray matter or neurons connecting to it) or all levels below the injury (damage to white matter).
- Example A: A patient has completely lost the use of their lower limbs, but upper-limb function is normal. You suspect that a complete spinal cord transection may be to blame. A transection at which spinal level(s) could account for the symptoms? Explain your reasoning.

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TQT 13.5.3. **Example A:** A transection anywhere from T_2 to T_{11} would result in these symptoms by interrupting information flow to and from the lower limbs (lumbar and sacral plexuses) but allowing continued information flow to the upper limbs (brachial plexus).

TQT 13.5.3 (LG 5). Given a picture or description of damage to a specific area of the spinal cord or spinal nerves, predict symptoms (e.g., sensory vs. motor, upper limbs vs. lower limbs). Or vice versa (i.e., given symptoms, predict the area of damage).

- STRATEGY: Use any available clues to decide between sensory deficits vs. motor deficits vs. both, but also consider whether the deficit will be limited to a specific spinal level (damage to gray matter or neurons connecting to it) or all levels below the injury (damage to white matter).
- Example B: A herniated intervertebral disc pinches the L_3 dorsal root. What symptoms would you predict? Explain your reasoning.
- Example C: Make up an example and ask your classmates!

TQT 13.6.1 (LG 3). Given information about a reflex, classify it as somatic or visceral, monosynaptic or polysynaptic, and/or cranial or spinal.

- STRATEGY: Know the definitions of each binary choice well enough to apply them confidently.
- Example A: When your intestines begin to fill with food, a signal is sent to the brainstem, which initiates contraction of the smooth muscle in the abdominal wall and movement of the food through the intestines. (a) Is this reflex somatic or visceral? (b) Is it monosynaptic or polysynaptic? (c) Is it cranial or spinal? Briefly explain each choice.

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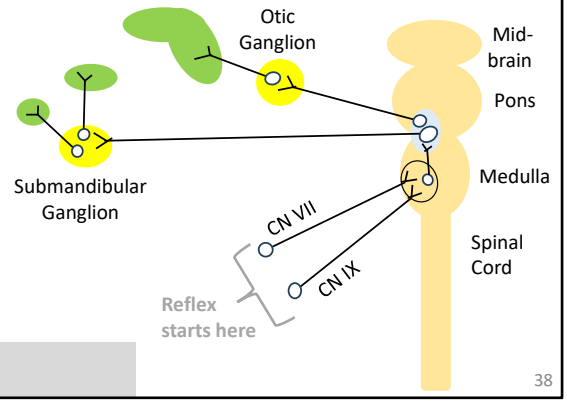
TQT 13.6.1. **Example A:** Visceral. (The effectors are not skeletal muscles.) Polysynaptic. (All visceral reflexes are polysynaptic, going through autonomic ganglia.) Cranial. (Goes through brain, not spinal cord.)

TQT 13.6.1 (LG 3). Given information about a reflex, classify it as somatic or visceral, monosynaptic or polysynaptic, and/or cranial or spinal.

- STRATEGY: Know the definitions of each binary choice well enough to apply them confidently.
- Example B: See the figure below, which covers reflex stimulation of the 3 green structures. Is that reflex somatic or visceral? Is it monosynaptic or polysynaptic? Is it cranial or spinal? Briefly explain.
- Example C: make up an example and ask your classmates!



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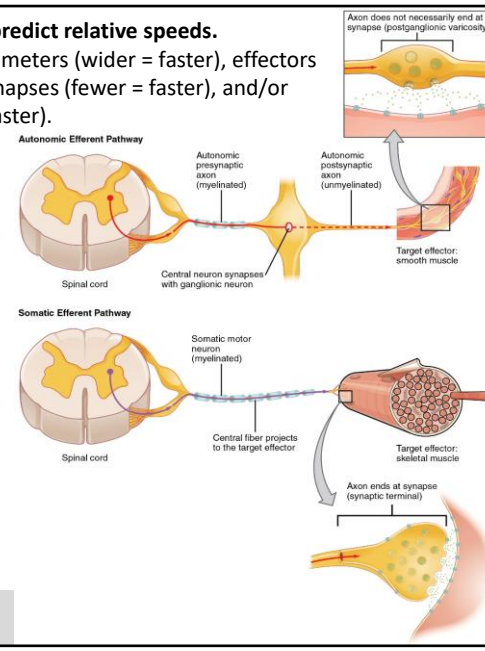
TQT 13.6.2 (LG 5). Given reflexes, predict relative speeds.

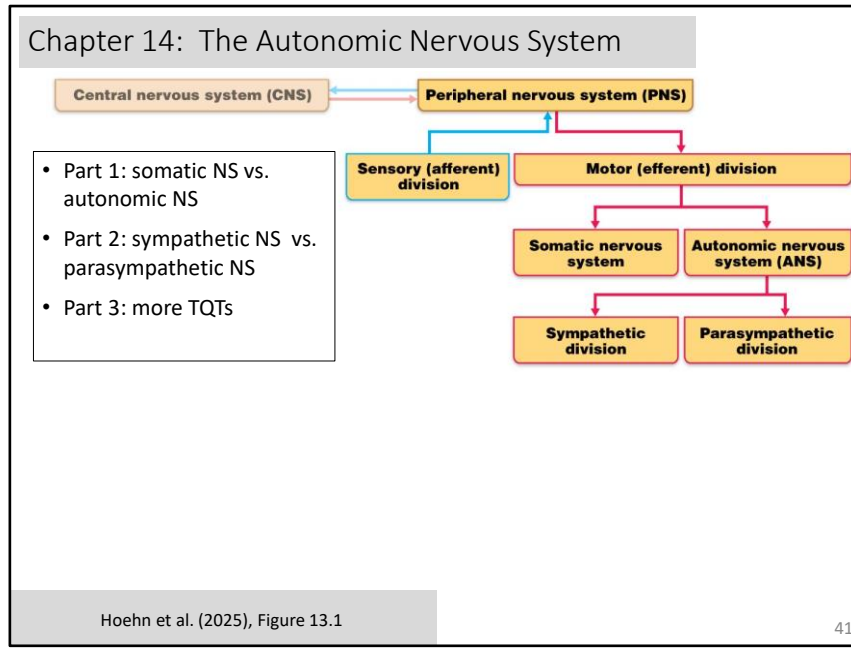
- STRATEGY: Consider the axon diameters (wider = faster), effectors (somatic = faster), number of synapses (fewer = faster), and/or degree of myelination (more = faster).
- Example A: Predict which reflex is faster, the crossed-extensor reflex (polysynaptic) or the patellar tendon reflex (monosynaptic)? Explain your reasoning.

TQT 13.6.2. **Example A:** The monosynaptic reflex should be faster, since there is only one synapse for signals to pass through. Also, somatic reflexes are generally faster than visceral/autonomic ones.

TQT 13.6.2 (LG 5). Given reflexes, predict relative speeds.

- STRATEGY: Consider the axon diameters (wider = faster), effectors (somatic = faster), number of synapses (fewer = faster), and/or degree of myelination (more = faster).
- Example B: Imagine that the motor (efferent) arms of two different reflexes are shown at right. Which motor response is slower, the top one or the bottom one? Explain your reasoning.
- Example C: make up an example and ask your classmates!

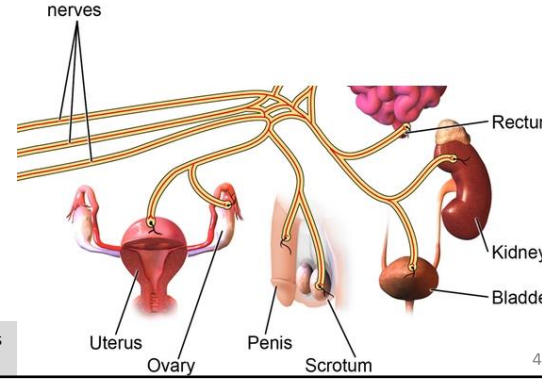




Somatic and autonomic: the 2 branches of the motor (efferent) nervous system. Somatic NS: activate skeletal muscles. Autonomic NS: adjust cardiac muscle, smooth muscle, glands.

TQT 14.1.1 (LG 3). Given a nervous system component, pathway, or effector, classify it as somatic motor or autonomic motor or neither.

- STRATEGY: A somatic motor pathway has single motor neurons stretching all the way from the CNS to skeletal muscle cells. If these facts do not apply, the pathway must be autonomic motor, or not motor at all.
- Example A: If the nerves pictured below are delivering input to the effectors pictured below, are these nerves a somatic motor pathway or an autonomic pathway? Explain your reasoning.



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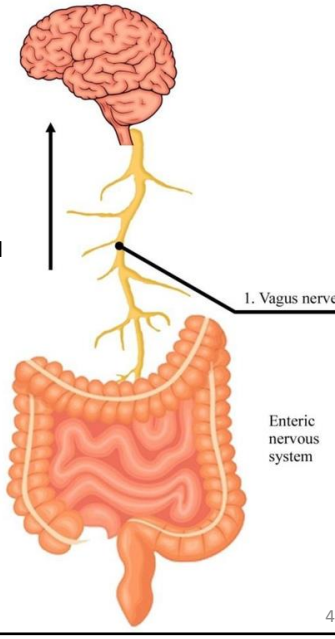
TQT 14.1.1. **Example A:** These effectors include smooth muscles and glands, not skeletal muscles, so the pathway is autonomic, not somatic.

TQT 14.1.1 (LG 3). Given a nervous system component, pathway, or effector, classify it as somatic motor or autonomic motor or neither.

- STRATEGY: A somatic motor pathway has single motor neurons stretching all the way from the CNS to skeletal muscle cells. If these facts do not apply, the pathway must be autonomic motor, or not motor at all.
- Example B: The figure at right shows an upward flow of nervous-system information from the colon toward the brain. Would this ascending pathway be considered somatic motor, autonomic, or neither? Explain your reasoning.
- Example C: Make up an example and ask your classmates!



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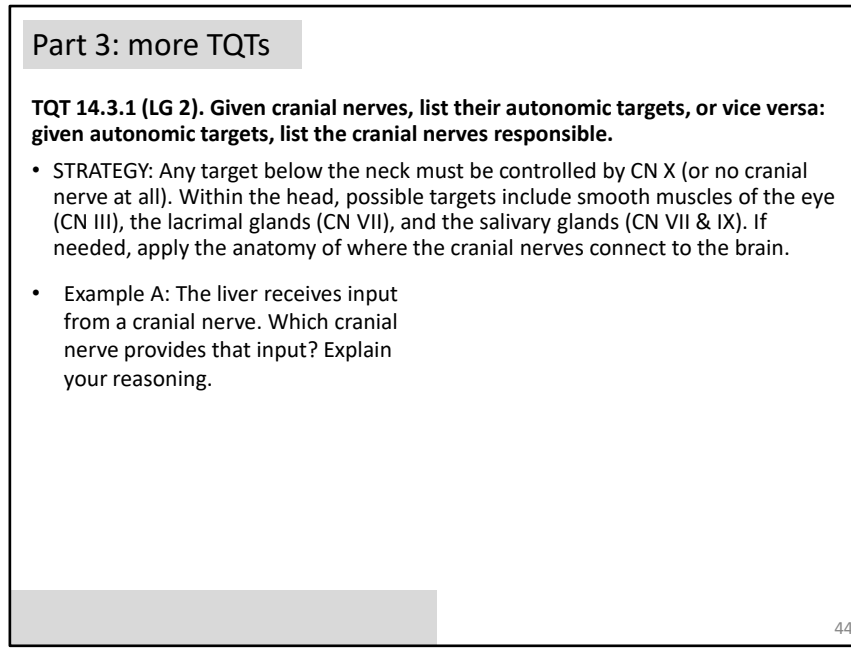
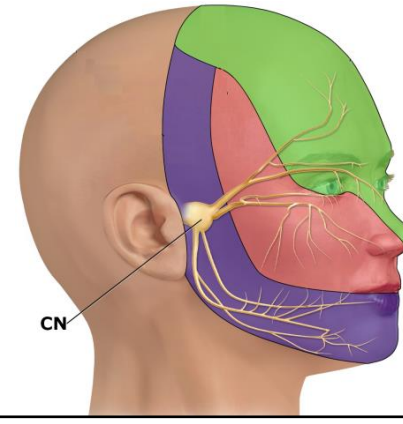


TQT 14.3.1. **Example A:** The liver is one of many abdominal organs that receives input from cranial nerve X (the vagus nerve).

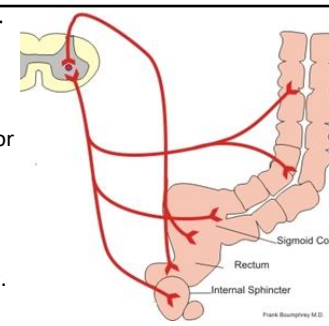
TQT 14.3.1 (LG 2). Given cranial nerves, list their autonomic targets, or vice versa: given autonomic targets, list the cranial nerves responsible.

- STRATEGY: Any target below the neck must be controlled by CN X (or no cranial nerve at all). Within the head, possible targets include smooth muscles of the eye (CN III), the lacrimal glands (CN VII), and the salivary glands (CN VII & IX). If needed, apply the anatomy of where the cranial nerves connect to the brain.
- Example B: In the picture at right, which autonomic target organ(s) receive input from the cranial nerve pictured? Explain your reasoning.
- Example C: Make up an example and ask your classmates!



TQT 14.3.2 (LG 1). Given information about a motor pathway, identify it as somatic, sympathetic, or parasympathetic.

- STRATEGY: Keep multiple criteria/clues in mind, as any given question may present only one portion or aspect of a pathway.
- Example A: See image at upper right. Are the preganglionic neurons shown in red part of a somatic pathway, a sympathetic pathway, or a parasympathetic pathway? Explain your reasoning.



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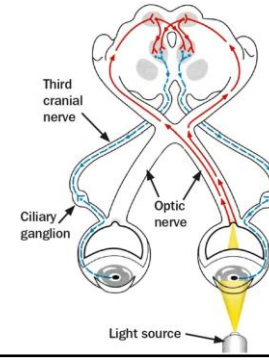
TQT 14.3.2. **Example A:** Parasympathetic. The target organs are not skeletal muscles, so that rules out somatic. The preganglionic neurons run just about all the way to the target organs, as opposed to stopping at a chain ganglion or collateral ganglion.

TQT 14.3.2 (LG 1). Given information about a motor pathway, identify it as somatic, sympathetic, or parasympathetic.

- STRATEGY: Keep multiple criteria/clues in mind, as any given question may present only one portion or aspect of a pathway.
- Example B: See image at lower right. Do the blue neurons make up a somatic pathway, a sympathetic pathway, or a parasympathetic pathway? Explain your reasoning.
- Example C: make up an example and ask your classmates!



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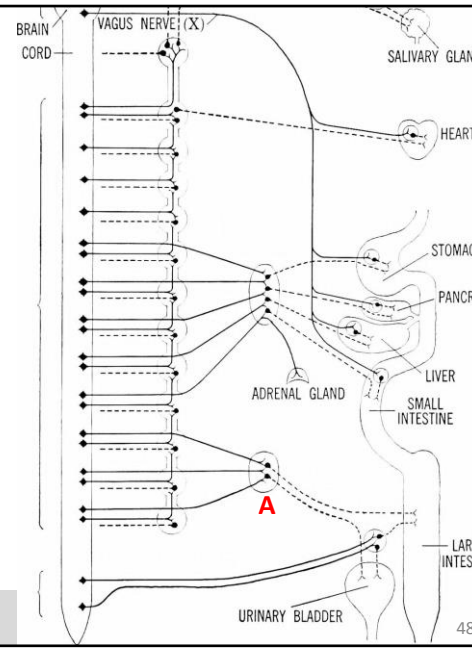
TQT 14.3.3 (LG 1). Given information about a ganglion, classify it as sensory or motor and/or as sympathetic or parasympathetic.

- STRATEGY: All ganglia below the head are motor except for the dorsal root ganglia. For sympathetic vs. parasympathetic, the usual clues are the proximity to the CNS (closer = sympathetic) and/or the origins of the preganglionic neurons (thoracolumbar = sympathetic).
- Example A: Find the ganglion marked with a red A. Is it sensory, sympathetic, or parasympathetic? Explain your reasoning.

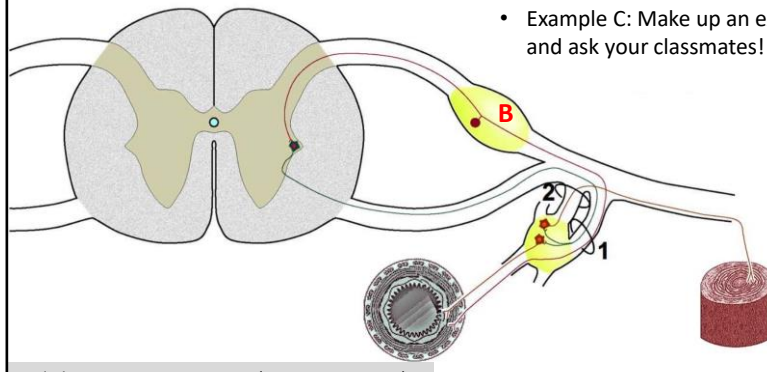


Douglas Marsland (1964) via Internet Archive Book Images on Flickr (public domain)

TQT 14.3.3. **Example A:** It comes from the thoracolumbar spinal cord, so it should be sympathetic. It is also relatively far away from the targets -- compare it to the other ganglion with neurons leading to the bladder and large intestine, which must be parasympathetic. ** (Most likely it is the inferior mesenteric ganglion.)

TQT 14.3.3 (LG 1). Given information about a ganglion, classify it as sensory or motor and/or as sympathetic or parasympathetic.

- STRATEGY: All ganglia below the head are motor except for the dorsal root ganglia. For sympathetic vs. parasympathetic, the usual clues are the proximity to the CNS (closer = sympathetic) and/or the origins of the preganglionic neurons (thoracolumbar = sympathetic).
- Example B: Find the ganglion below marked with a red B. Is it sensory, sympathetic, or parasympathetic? Explain your reasoning.
- Example C: Make up an example and ask your classmates!



Flickr user EUSKALANATO (CC BY NC SA 2.0)

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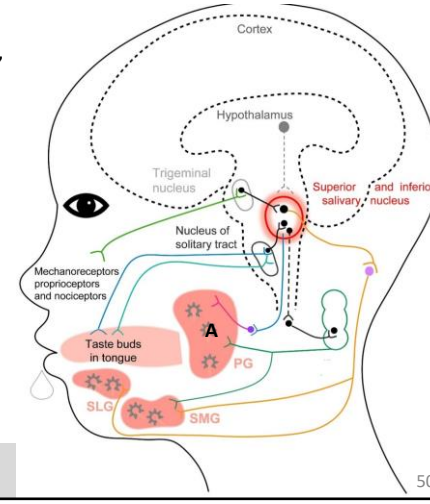
TQT 14.3.4 (LG 2). Given information about autonomic nervous system pathways, predict the neurotransmitter released by a given neuron.

- STRATEGY: The neurotransmitter released is acetylcholine (ACh) by preganglionic axons (within ganglia) and by postganglionic parasympathetic axons, but it's norepinephrine (NE) by postganglionic sympathetic axons (except for sweat glands).
- Example A: At right we see three salivary glands: the parotid gland (PG), the submandibular gland (SMG), and the sublingual gland (SLG). Which neurotransmitter will be released at location A? Explain your reasoning.



Yu Feng Shang et al. (2023), *Front. Endocrinol.* 14: 1061235 (CC BY 4.0)

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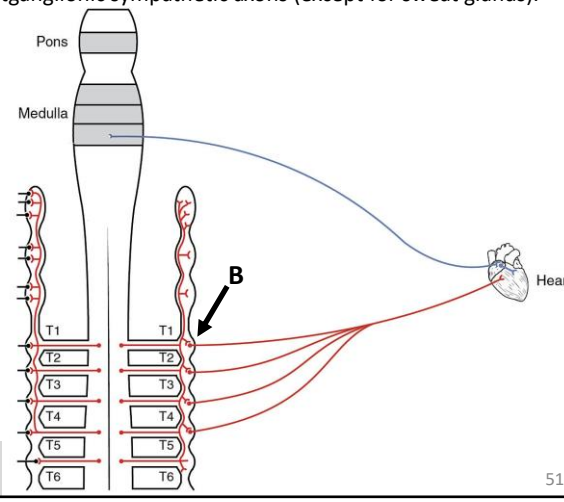
TQT 14.3.4. **Example A:** Location A is at the end of a pathway that appears to exit the CNS lower down than the other pathway innervating the PG (spinal cord rather than brainstem) and that appears go through a cervical chain ganglion, consistent with it being sympathetic. The other pathway has a ganglion very close to the salivary gland, consistent with it being parasympathetic. Therefore if location A is the end of a sympathetic neuron terminating on the salivary gland, the neurotransmitter should be norepinephrine.

TQT 14.3.4 (LG 2). Given information about autonomic nervous system pathways, predict the neurotransmitter released by a given neuron.
STRATEGY: The neurotransmitter released is acetylcholine (ACh) by preganglionic axons (within ganglia) and by postganglionic parasympathetic axons, but it's norepinephrine (NE) by postganglionic sympathetic axons (except for sweat glands).

- Example B: Which neurotransmitter is released at the location marked at right with a "B"? Explain your reasoning.
- Example C: Make up an example and ask your classmates!



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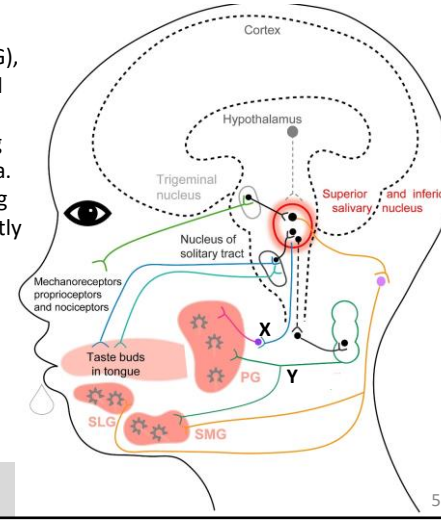
TQT 14.3.5 (LG 2). Given information about a person's physiological state, make predictions about the activity of their autonomic nervous system, or vice versa.

- STRATEGY: Recognize pathways as sympathetic or parasympathetic (as in previous TQTs) and correlate those with signs/symptoms.
- Example A: At right we see three salivary glands: the parotid gland (PG), the submandibular gland (SMG), and the sublingual gland (SLG). At the moment, these glands are producing small amounts of thick, viscous saliva. Predict which nervous pathway going to the parotid gland, X or Y, is currently more active. Explain your reasoning.



Yu Feng Shang et al. (2023), *Front. Endocrinol.* 14: 1061235 (CC BY 4.0)

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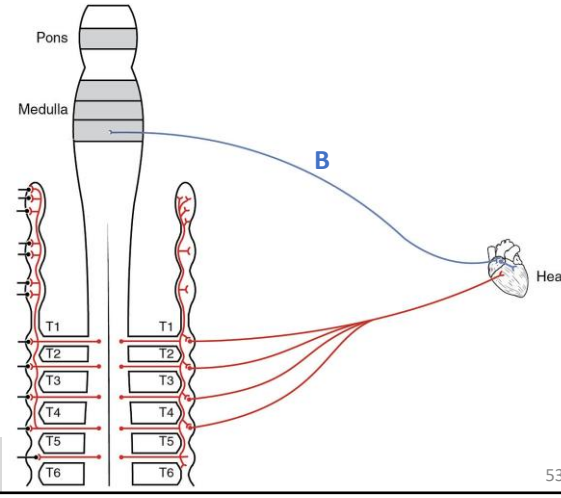
TQT 14.3.5. **Example A:** Viscous saliva is consistent with a fight-or-flight response and activation of the sympathetic NS, which is pathway Y. Pathway Y appears to exit the CNS lower down than pathway X (spinal cord rather than brainstem) and to go through a cervical chain ganglion, consistent with it being sympathetic. Pathway X has a ganglion very close to the salivary gland, consistent with it being parasympathetic.

TQT 14.3.5 (LG 2). Given information about a person's physiological state, make predictions about the activity of their autonomic nervous system, or vice versa.

- STRATEGY: Recognize pathways as sympathetic or parasympathetic (as in previous TQTs) and correlate those with signs/symptoms.

- Example B: The nervous pathway marked with a "B" at right is currently highly active. What will be the effect on the heart? Explain your reasoning.
- Example C: Make up an example and ask your classmates!



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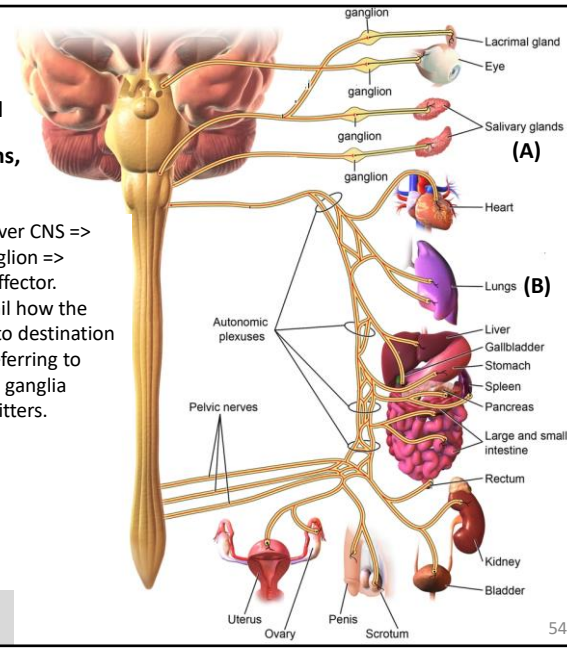
TQT 14.3.6 (LG 6). Given a picture of an autonomic pathway, describe how a nervous system signal gets from the CNS to designated effector(s), referring to specific CNS origins, neurons, synapses, and neurotransmitters.

- STRATEGY: Be thorough! Cover CNS => neuron 1 => synapse in ganglion => neuron 2 => synapse with effector.
- Example A: Describe in detail how the nervous system gets signal to destination A by the pathway shown, referring to specific CNS parts, neurons, ganglia locations, and neurotransmitters.



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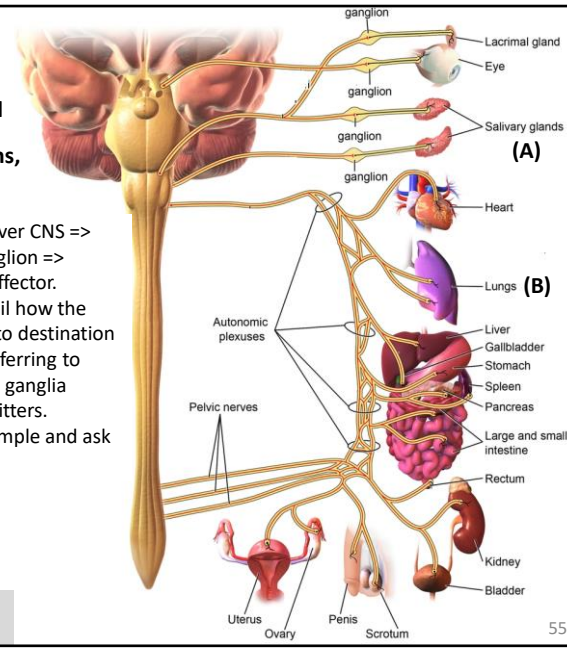
TQT 14.3.6. **Example A:** The pathway shown starts in the brainstem. Axons exit the brainstem via cranial nerves (VII and IX). These preganglionic neurons synapse in ganglia in the head, releasing acetylcholine to the postganglionic neurons, which travel the rest of the way to the salivary glands, where they release acetylcholine, stimulating the glands to secrete watery saliva.

TQT 14.3.6 (LG 6). Given a picture of an autonomic pathway, describe how a nervous system signal gets from the CNS to designated effector(s), referring to specific CNS origins, neurons, synapses, and neurotransmitters.

- STRATEGY: Be thorough! Cover CNS => neuron 1 => synapse in ganglion => neuron 2 => synapse with effector.
- Example B: Describe in detail how the nervous system gets signal to destination B by the pathway shown, referring to specific CNS parts, neurons, ganglia locations, and neurotransmitters.
- Example C: Make up an example and ask your classmates!



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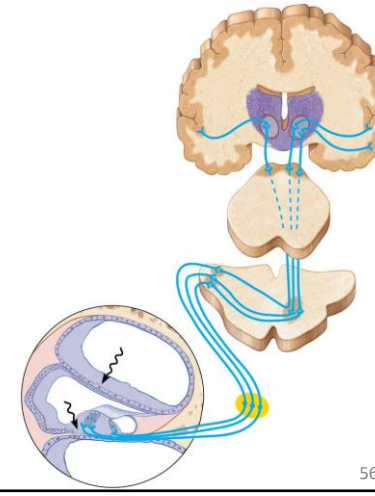
Biology 231 (Human Anatomy)

Chapter 15: The Nervous System: The Special Senses

- Part 1: general review of sensation
- Part 2: the five special senses
- Part 3: pre-receptor biophysics (light, sound)
- Part 4: sensory pathways



Hoehn et al. (2025), Figure 15.33

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Chapter 15 – the final chapter in our series on the nervous system. We'll go over the sensing of stimuli as covered in the textbook, then we'll look a bit more broadly at the PATHWAYS of sensory info (from periphery to brain), which incorporates some information from earlier chapters.

TQT 15.1.1 (LG 3). Given a sensory receptor cell, classify it according to structure (neuron or non-neuron; unipolar or bipolar) and/or location/function (exteroceptor, interoceptor, or proprioceptor; chemoreceptor, mechanoreceptors, nocicepter, osmoreceptor, photoreceptor, or thermoreceptor).

- STRATEGY: Apply the definitions of the categories listed above.
- Example A: A particular cutaneous receptor is most active when the skin is at 77^{o} Fahrenheit, and less active at other skin temperatures. Is this an exteroceptor, interoceptor, or proprioceptor? Explain your reasoning.

Stupnikov & Cardoso (2017), *eLife* 6: e21231

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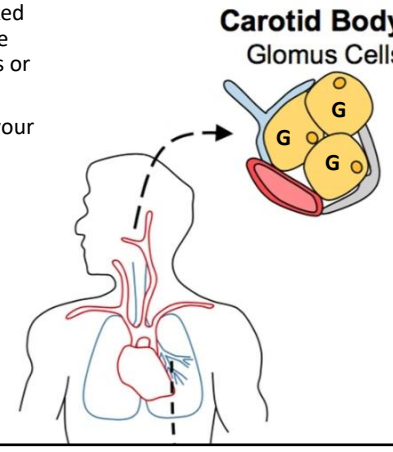
TQT 15.1.1. **Example A:** This is an exteroceptor, sensing the external stimulus of external temperature -- and a thermoreceptor, which senses external temperature.

TQT 15.1.1 (LG 3). Given a sensory receptor cell, classify it according to structure (neuron or non-neuron; unipolar or bipolar) and/or location/function (exteroceptor, interoceptor, or proprioceptor; chemoreceptor, mechanoreceptors, nocicepter, osmoreceptor, photoreceptor, or thermoreceptor).

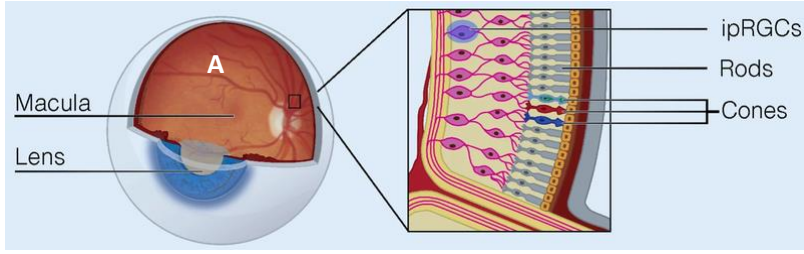
- STRATEGY: Apply the definitions of the categories listed above.
- Example B: The glomus cells (yellow, marked with G's at right) monitor the blood for the presence of oxygen (O_2). Are they neurons or not? Explain your reasoning.
- Example C: make up an example and ask your classmates!



Stupnikov & Cardoso (2017), *eLife* 6: e21231

TQT 15.3.1 (LG 1). Given a location in the eye, describe the relative abundance of rods and/or cones.

- STRATEGY: Apply the knowledge that photoreceptors are found only in the retina, with cones most abundant in the fovea and rods predominating elsewhere.
- Example A: Are there any/many rods and/or cones at the location marked A below? Explain your reasoning.



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TQT 15.3.1. **Example A:** This is a "regular" part of the retina (not the macula, not the optic disc), so it should have mostly rods with some cones as well.

TQT 15.3.1 (LG 1). Given a location in the eye, describe the relative abundance of rods and/or cones.

- STRATEGY: Apply the knowledge that photoreceptors are found only in the retina, with cones most abundant in the fovea and rods predominating elsewhere.
- Example B: Are there any/many rods and/or cones at the lens? Explain your reasoning.
- Example C: Make up an example and ask your classmates!

TQT 15.3.2 (LG 5). Given a physical change or physical limitation of the eye (lens, eyeball length) or ear (tympanic membrane, oval window, basilar membrane), explain how the function would be affected.

- STRATEGY: Apply your knowledge of how these parts' functions arise directly from their physical properties.
- Example A: When a patient views up-close pictures, their lens cannot thicken enough to bring the images into focus on the retina. In that situation, would the focal point be in front of the retina, or behind the retina? Explain your reasoning.

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TQT 15.3.2. **Example A:** Behind the retina. The challenge of nearby images is whether they can be focused/shrunk enough to get them onto the retina in focus. Here the answer is no; extra distance is needed before the images come into focus.

TQT 15.3.2 (LG 5). Given a physical change or physical limitation of the eye (lens, eyeball length) or ear (tympanic membrane, oval window, basilar membrane), explain how the function would be affected.

- STRATEGY: Apply your knowledge of how these parts' functions arise directly from their physical properties.
- Example B: Imagine a person whose basilar membrane (in the cochlea) is of uniform thickness from the oval window to the helicotrema (see image below). How would this affect the detection of sound? Explain your reasoning.
- Example C: Make up an example and ask your classmates!

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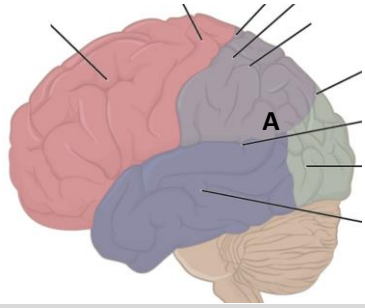
TQT 15.4.1 (LG 5). Given a part of a sensory pathway, determine whether that part carries information on balance/equilibrium, hearing, both, or neither.

- STRATEGY: Know the parts of both pathways in order to identify whether a given structure is part of one or the other or (for cranial nerve VIII) both.
- Example A: Below at left, is area "A" part of the balance/equilibrium pathway, the auditory pathway, both, or neither? Explain your reasoning.



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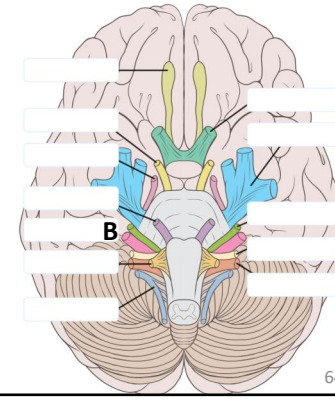
TQT 15.4.1. **Example A:** "A" marks a part of the parietal lobe, which does process balance/equilibrium information but does not process auditory information (that's done in the temporal lobe), so this spot is balance/equilibrium only.

TQT 15.4.1 (LG 5). Given a part of a sensory pathway, determine whether that part carries information on balance/equilibrium, hearing, both, or neither.

- STRATEGY: Know the parts of both pathways in order to identify whether a given structure is part of one or the other or (for cranial nerve VIII) both.
- Example B: Below at right, is pink structure "B" part of the balance/equilibrium pathway, the auditory pathway, both, or neither? Explain your reasoning.
- Example C: Make up an example and ask your classmates!



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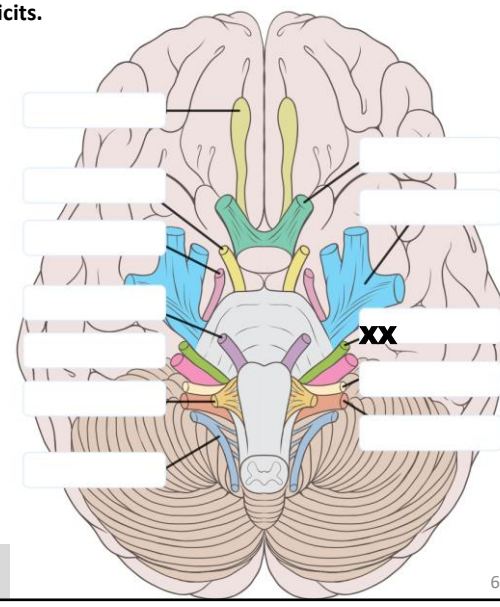
TQT 15.4.2 (LG 5). Given a location of nervous system damage, make predictions about resulting special-sense deficits.

- STRATEGY: Identify the structure, then recall the structure's function(s).
- Example A: There is damage to the green structure labeled with a black XX at right. Which special sense(s) is/are likely to be most affected? Explain your reasoning.



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TQT 15.4.2. **Example A:** The damage is to cranial nerve VII, the facial nerve, which carries taste information from the tongue, so the sense of taste may be impaired. Nerve VII also helps control saliva production, so that may be impaired too.

TQT 15.4.2 (LG 5). Given a location of nervous system damage, make predictions about resulting special-sense deficits.

- STRATEGY: Identify the structure, then recall the structure's function(s).
- Example B: Imagine that there is damage to a pathway that runs from the thalamus to the insula. What special-sense symptoms are likely to result? Explain your reasoning.
- Example C: Make up a question and ask your classmates!

TQT 15.4.3 (LG 5). Given damage to a specific part of the visual pathway, predict symptoms arising from damage.

- STRATEGY: Determine whether the damage occurred anterior to the optic chiasm (affecting info from one eye, possibly from both sides of the environment) or posterior to the optic chiasm (affecting info from one side of the environment, possibly from both eyes).
- Example A: If there is a severe injury along the left optic nerve, how will the person's vision be affected? Be specific; explain your answer.

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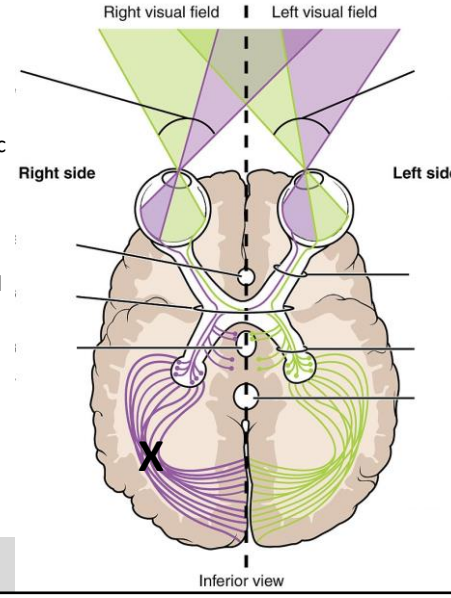
Consider focusing partly on the 1-eye-only parts of the environment. ** TQT 15.4.3. **Example A:** The optic nerve carries information on both the left and right sides of the environment, so perception of both sides could be affected, but especially the peripheral "left-eye-only" area of the environment, which cannot be seen by the right eye.

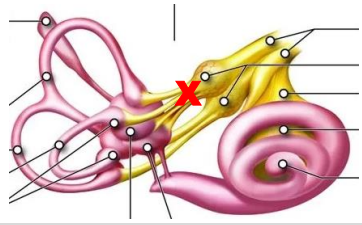
TQT 15.4.3 (LG 5). Given damage to a specific part of the visual pathway, predict symptoms arising from damage.

- STRATEGY: Determine whether the damage occurred anterior to the optic chiasm (affecting info from one eye, possibly from both sides of the environment) or posterior to the optic chiasm (affecting info from one side of the environment, possibly from both eyes).
- Example B: If there is a severe injury at the X in the figure at right, how will the person's vision be affected? Be specific; explain your answer.
- Example C: Make up an example and ask your classmates!



TQT 15.4.4 (LG 3). Given damage to a specific location of the head/brain, identify the likely consequence as conductive hearing loss, sensorineural hearing loss, or neither.

- STRATEGY: Apply the fact that conductive problems are along the path from the outside of the ear to the hair cells of the cochlea, while sensorineural problems are with the hair cells themselves or the neurons downstream of them.
- Example A: In the structure pictured below at left, there is damage at the red "X." Would this lead to conductive hearing loss, sensorineural hearing loss, or neither? Explain your reasoning.



Cenveo via BrainMadeSimple.com (CC BY 3.0)

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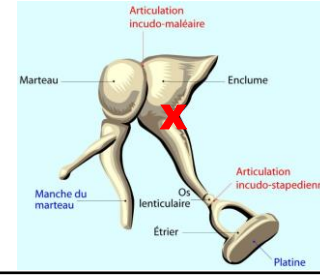
TQT 15.4.4. **Example A:** Neither. Here the vestibular branch of nerve VIII is damaged, but the cochlear branch is fine as far as we know, so there shouldn't be any hearing loss (only an impairment of balance).

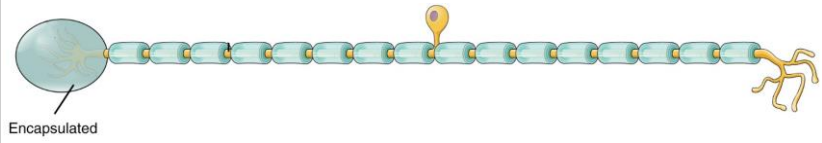
TQT 15.4.4 (LG 3). Given damage to a specific location of the head/brain, identify the likely consequence as conductive hearing loss, sensorineural hearing loss, or neither.

- STRATEGY: Apply the fact that conductive problems are along the path from the outside of the ear to the hair cells of the cochlea, while sensorineural problems are with the hair cells themselves or the neurons downstream of them.
- Example B: In the structure pictured below at right, there is damage at the red "X." Would this lead to conductive hearing loss, sensorineural hearing loss, or neither? Explain your reasoning.
- Example C: Make up an example and ask your classmates!



TQT 15.4.5 (LG 3). Given a nervous system component, classify it as sensory, somatic motor, or autonomic motor (sympathetic or parasympathetic).

- STRATEGY: Apply any relevant clues covered in Chapters 11-15.
- Example A: Is the neuron below part of a sensory, somatic motor, sympathetic, or parasympathetic pathway? Explain your reasoning.



TQT 15.4.5. **Example A:** This is a sensory neuron. You can tell from the encapsulation (only sensory neurons are encapsulated) and also from the unipolar shape.

TQT 15.4.5 (LG 3), continued.

- Example B: At right there is a red neuron that begins in the hypothalamus. Predict whether the information carried by this neuron is sensory, somatic motor, or autonomic motor. Explain your reasoning.
- Example C: Make up an example and ask your classmates!